chemists until Mr. Perkin successfully grappled with the subject in 1856, and produced the beautiful colouring matter known as aniline violet, or mauve, the production of which, on a large scale, by Mr. Perkin, laid the foundation of the coal tar colour industry.

His more recent researches on anthracene derivatives, especially on artificial alizarine, the colouring matter identical with that obtained from madder, rank among the most important work, and some of them have greatly contributed to the successful manufacture of alizarine in this country, whereby we have been rendered independent of the importation of madder.

Among the very numerous researches of purely scientific interest which Mr. Perkin has published, a series on the hydrides of salicyl and their derivatives, may be specially referred to; but among the most prominent of his admirable investigations are those resulting in the synthesis of coumarin, the odoriferous principle of the tonquin bean and the sweet scented woodruff, and of its homologues.

The artificial production of glycocol and of tartaric acid by Mr. Perkin conjointly with Mr. Duppa, afford other admirable examples of synthetical research, which excited very great interest among chemists at the time of their publication.

It is seldom that an investigator of organic chemistry has extended his researches over so wide a range as is the case with Mr. Perkin, and his work has always commanded the admiration of chemists for its accuracy and completeness, and for the originality of its conception.

A Royal Medal has been awarded to A. C. Ramsay, F.R.S. Prof. Ramsay has been for a period of nearly forty years connected with the Geological Survey of Great Britain, and during by far the greater part of that time either as Director or Director-General of the Survey. During this long period, in addition to his official labours in advancing our knowledge of the geology of this country, he has published works on the "Geology of Arran," "The Geology of North Wales," "The Old Glaciers of North Wales and Switzerland," and "The Physical Geology and Geography of Great Britain," now in its fifth edition. (His papers in the *Quarterly Journal* of the Geological Society, and elsewhere, are numerous and important, especially those on theoretical questions in physical geology, such for instance, as "The Glacial Origin of Lake Basins," "The Freshwater Formation of the Older Red Rocks," and "The History of the Valley of the Rhine, and other Valleys of Erosion." There are, indeed, among living geologists few who can claim to have done more to extend our knowledge in the important fields of geology and physical geography.

The Davy Medal has been awarded to P. E. Lecoq de Boisbaudran. The discovery of the metal gallium is remarkable for having filled a gap which had been previously pointed out in the series of known elements. Mendelejeff had already shown that a metal might probably exist, intermediate in its properties between aluminium aud indium, before Boisbaudran's laborious spectroscopic and chemical investigation of numerous varieties of blende led him to the discovery and isolation of such a metal.

The separation of the minute traces of gallium compounds from blende is an operation presenting unusual difficulty, owing to the circumstance that compounds of gallium are carried down by various precipitates from solutions which are incapable by themselves of depositing those compounds.

EXPERIMENTAL DETERMINATION OF THE VELOCITY OF LIGHT[1]

II.

FIG. 7 represents a plan of the lower floor of the building. E is a three horse power Lovegrove engine and boiler, resting on a stone foundation; B, a small Roots' blower; G, an automatic regulator. From this the air goes to a delivery pipe up through the floor to the turbine. The engine made about four turns per second, and the blower about fifteen. At this speed the pressure of the air was about half a pound per square inch.

The regulator, Fig. 8, consists of a strong bellows, supporting a weight of 370 pounds, partly counterpoised by 80 pounds, in order to keep the bellows from sagging. When the pressure of the air from the blower exceeds the weight, the bellows commences to rise, and in so doing closes the valve, V.

This arrangement was found in practice to be insufficient, and the following addition was made: a valve was placed at P, and the pipe was tapped a little farther on, and a rubber tube led to a water gauge, Fig. 9. The column of water in the smaller tube is depressed, and when it reaches the horizontal part of the tube, the slightest variation of pressure sends the column from one end to the other. This is checked by an assistant at the valve, so that the column of water is kept at nearly the same point, and the pressure thus rendered very nearly constant. The result was satisfactory, though not in the degree anticipated. It was possible to keep the mirror at a constant speed for three or four seconds at a time, and this was sufficient for an observation. Still it would have been more convenient to have kept it so for a longer time. The test of uniformity was, however, very sensitive, as a change of speed of 0·02 of a revolution per second could be detected.

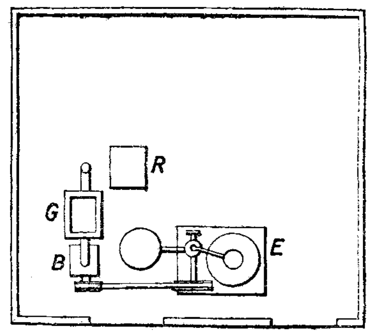

FIG. 7.

It was found that the only time during the day when the atmosphere was sufficiently quiet to get a distinct image was during the hour after sunrise or during the hour before sunset. At other times the image was "boiling," so as not to be recognisable. In one experiment the electric light was used at night, but the image was no more distinct than at sunset, and the light was unsteady.

The method followed in experiment was as follows:—The fire was started half an hour before, and by the time everything was ready the gauge would show 40 or 50 lbs. of steam. The mirror was adjusted by signals as before described. The heliostat was placed and adjusted. The revolving mirror was adjusted by being moved about till the light returned to it from the distant mirror. The axis of the revolving mirror was also inclined to the right or the left, so that the direct reflection of light from the slit fell above or below the eyepiece, as otherwise this light would overpower that from the reflection from the distant mirror, &c., which forms the image to be observed. This inclination of the axis of rotation introduces a small error, which is duly allowed for in the calculations.

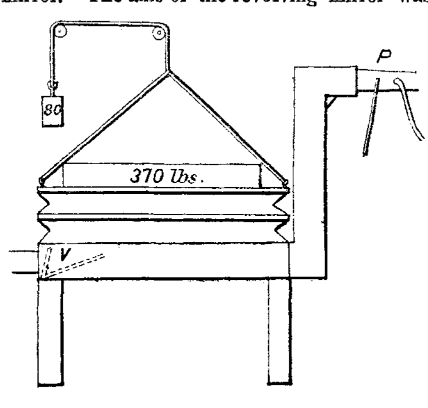

FIG. 8.

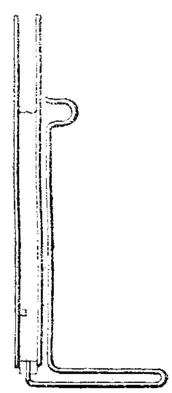

FIG. 9.

The distance between the front face of the mirror and the cross hair of the eyepiece was then measured, by stretching from one to the other a steel tape, making the drop of the catenary about an inch—when the error on account of the curve, and that due to the stretching of the tape, just counterbalanced each other.

The position of the slit, if not determined before, was then

[1] By Albert A. Michelson, Master, U.S. Navy. Read before the American Association. Continued from p. 96.

found as before described. The electric fork was then started, the temperature noted, and the beats between it and the standard fork counted for 60 seconds. This was repeated two or three times before every set of observations.

The eyepiece of the micrometer was then set approximately, and the revolving mirror started. If the image did not appear, the mirror was inclined forward or backward till it came in sight.

The cord connected with the valve was pulled right or left, till the images of the revolving mirror, represented by the two round spots to the left of the cross hair, came to rest. Then the screw was turned till the cross hair bisected the deflected image of the slit. This was repeated till ten observations were taken, when the mirror was stopped, temperature noted, and beats counted. This was called a set of observations. Usually five such sets were taken morning and evening.

The steel tape used was one of Chesterman's, 100 feet long. It was carefully compared with the copy of the standard yard made by Wurdemann, by a comparator. The result showed that the error of the tape was 0·006 foot. The true length was 100·006 feet.

The micrometer was also compared with the standard yard and the standard meter, the first giving for the value of one scale division, 0·99650 mm.
and the second, 0·99642 ,,

Mean ... ... 0·99646 mm.

One turn of the screw was found equal to 1·0009 divisions. Hence the value of one turn was 0·99655 millimeter.

The distance between the pier for the revolving mirror and the stationary mirror was measured by means of the steel tape. Square lead weights were placed along the line, and measurements taken from one to the other, the tape resting on the ground and stretched by a force of 10 pounds. The measurements, five in all, were all made at about 62° F. The results are:—

1985·13
1985·17
1984·93
1985·09
1985·09

Mean ... ... 1985·082

Correction for stretch of tape	0·33
,, ,, length ,, ...	0·12
Distance from pier to revolving mirror ...	0·70
Total correction	1·15
	1985·08
True distance	1986·23

The rate of vibration of the standard fork armed with a tip of copper foil was found by allowing it to trace its record on the lampblacked cylinder of a Schultz's chronoscope. The time was given either by a sidereal break-circuit chronometer or by a mean time clock. In the former case the break circuit worked a relay which interrupted the current from three Grove cells. In the latter, the circuit was broken by the pendulum. The spark from the secondary coil of a Ruhmkorff was delivered from a wire near the tip of the fork. The rate of the chronometer, the record of which was kept at the Observatory, was very regular. It was found, from observations of transits of stars during the week, to be + 1·3 seconds per day, which is the same as the recorded rate.

The correction for temperature was found by Prof. Mayer to be + 0·012 v.s. for a diminution of 1° F.

My own result was + 0·0125 v.s.

Adopted + 0·012.

The following is the table of results:—

256·069
256·089
256·077
256·012
256·087
256·074
256·061
256·100
256·084
256·066

Mean ... ... 256·072

In one of these observations I counted the beats between this fork and another, first while the former was tracing its record, and then when it was free and in position as for use. The difference, if any, was less than 0·01 v.s.

As the result obtained depends directly on the rate of vibration of the fork, I was not willing to trust entirely to my own work, and asked Prof. Mayer to make a determination.

He kindly offered to make it together with myself. Accordingly, I went to the Hoboken Institute, and a series of ten determinations were made under the following conditions:—

The fork was wedged into a wooden support, and the tip allowed to rest on lampblacked paper wound about a metal cylinder, which was turned by hand. Break-circuit clock was used, the rate of which was ascertained by comparison with the Western Union time-ball. The spark from the Ruhmkorff passed from the tip of metal attached to the fork, piercing the paper. Size of the spark was regulated by resistances.

Table of results was as follows:—

256·072
256·126
256·091
256·108
256·068
256·090
256·112
256·124
256·080
256·070

Mean ... ... 256·094

The effect of scrape was sought for again, and found to be 0·003 v.s.

The effect of the support, however, was greater, both combined being − 0·026 v.s.

Making this correction, the result becomes:—

256·068
Former result ... 256·072

Mean ... ... 256·070 vibrations per second, at 65° F.

The formulæ employed in the calculations are:—

$$(1) \quad \ldots \quad \ldots \quad \ldots \tan\phi = \frac{d_1}{r}$$

$$(2) \quad \ldots \quad \ldots \quad \ldots \quad V = \frac{2592000'' \times D \times n}{\phi''}.$$

Where ϕ = angle of deflection.
d_1 = displacement, or $r \, . \tan\phi$.
r = radius of measurement.
D = twice the distance between mirrors.
n = number of revolutions per second.
α = inclination of plane of rotation.
V = velocity.

D and r are expressed in feet, and d_1 in millimetres.

Substituting for d_1 its value,

$$d \times 0{\cdot}99655 \times \sec\alpha,$$

where d_1 is the displacement in turns of screw,
and $\log\sec\alpha = 0{\cdot}00008$,
we have, reducing to kilometres:—

$$(3) \quad \ldots \quad \ldots \quad \tan\phi = c_1 \frac{d}{r} \qquad \log c_1 = 0{\cdot}51457$$

$$(4) \quad \ldots \quad \ldots \quad \ldots \quad V = c\,\frac{n}{\phi} \qquad \log c = 0{\cdot}49670$$

In the calculations the effect of temperature on the screw, scale, and tape used in finding ρ was neglected. It can be applied to the final result for the mean temperature, which was 75·6° F.

Correction for tan ϕ is − 0·000003 × 13·1 = − 0·0004.

Correction for V is + 12 kilometres.

The direction of rotation was right-handed. To eliminate any possible error on this account, the mirror in eight of the later observations was inverted, thus making the rotation left-handed, and the deflection measured to the left. The results were the same as before, within the limits of error.

To eliminate errors due to a regular variation in speed during every revolution, if any such could exist, the position of the frame was changed in several experiments. The results were the same as before.

To test the question as to whether the vortex of air about the mirror had any effect on the deflection, the speed was lowered to 192, 128, 96, and 64 turns per second. If the vortex had any effect, it should have decreased with the lower speed, but no such effect could be detected.

Finally, to test if there were any bias in making the observations, the readings in several sets were taken by another, and the results written down without divulging them. The separate readings, as will be shown in the following specimen, were as consistent as when made by myself, and the final results agree with those of other observations:—

Specimen of Observations

June 17, Sunset. Image good (best in column 4).

	(1)	(2)	(3)	(4)	(5)
	112·81	112·80	112·83	112·74	112·79
	112·81	112·81	112·81	112·76	112·78
	112·79	112·78	112·78	112·74	112·74
	112·80	112·75	112·74	112·76	112·74
	112·79	112·77	112·74	112·76	112·77
	112·82	112·79	112·72	112·78	112·81
	112·76	112·73	112·76	112·78	112·77
	112·83	112·78	112·81	112·79	112·75
	112·78	112·79	112·74	112·83	112·82
	112·82	112·73	112·76	112·78	112·82
Means =	112·801	112·773	192·769	112·772	112·779
Zero =	0·260	0·260	0·260	0·260	0·260
d =	112·541	112·513	112·509	112·512	112·519

Temp. = 77°, B = + 1·500, cor. = − 0·144, diff. = + 1·356, added to 256·070 = 257·426 = *n*
28·155 = *r*

Results from the above.

299,660 299,740 299,740 299,740 299,720

Data for Working out Observations

Ut_3 fork makes 256·070 vibr. per sec. at 65° F.
D = 3,972·46 feet.
tan α = tangent of inclination of plane of rotation = 0·02.
c_1 = log = 0·51457.
c = log = 0·49670.
d = deflection as read from micrometer.
r = radius.
ϕ = angle of deflection.
n = number of revolutions per second.
V = velocity of light in kilometres.
B = number of beats per second between electric Ut_2 fork and standard Ut_3 fork. Electric fork makes $\frac{1}{2}$ (256·07 + B + cor.) vibr. per second, and n is a multiple submultiple or simple ratio of this.
Cor. = correction for temperature of standard,
= − 0·012 v.s. per degree F.

Mean result[1]	299,728
Cor. for temp.	+12
Vel. of light in air	299,740
Cor. for vacuum	+88

Vel. of light *in vacuo* = 299,828 kilometres per second.

SCIENTIFIC SERIALS

American Journal of Science and Arts, November.—Mr. Stockwell, who has been systematically examining the physical theory of the moon's motion, here calls attention to a secular inequality in that motion, produced by the oblateness of the earth. For attracted points out of the plane of the equator, and not beyond the parallels of 35° 16′ (which is the moon's case), the attraction of the earth is less than it would be if the latter were spherical. The author says he has found several inequalities in the moon's motion, not recognised by existing theories, and of even greater practical importance than the foregoing.—The diamagnetic constants of bismuth and calc-spar in absolute measure have been determined by Prof. Rowland and Mr. Jacques. In their paper the former develops mathematical expressions for the various coefficients of magnetisation, while the latter describes the experimental method adopted: first, exploration of the field, and then noting the time of swing of little suspended bars of the substances in it. The constants for bismuth are

$$\left\{\begin{array}{l} k_1 = -\cdot 000000012554 \\ k_2 = -\cdot 000000014324 \end{array}\right\};$$

for calc-spar,

$$\left\{\begin{array}{l} k_1 = -\cdot 000000037930 \\ k_2 = -\cdot 000000040330 \end{array}\right\}.$$

—Mr. Gibbs's elaborate paper on vapour-densities is here concluded. The relation between temperature, pressure, and volume for the vapours of peroxide of nitrogen, formic acid, acetic acid, and perchloride of phosphorus, differs widely from that expressed by the usual laws, and the hypothesis of a compound nature of the vapour is probable. Mr. Gibbs had proposed equations to express the relations between temperature, pressure, or volume, and quantities of the components in such a "gas mixture of convertible components." In his paper he reviews all known experimental determinations of the vapour densities, and finds fair agreement with formula.—We note also accounts of Mr. Michelson's recent experimental determination of the velocity of light; of the remarkable Kane Geyser well (arising from a conflict between gas and water in a petroleum region), and of Mr. Edison's resonant tuning fork.—Besides Prof. Marsh's recent address, there are further notes by him of new Jurassic mammals from the Rocky Mountains, showing a resemblance to known types of the Purbeck in England.

The American Naturalist, vol. xiii. No. 11, November, contains:—B. B. Redding, How our ancestors in the Stone Age made their implements; Isaac C. Martindale, Colorado plants; C. G. Siewers, Mould as an insect destroyer; W. N. Lockington, Notes on Pacific Coast fishes and fisheries; William Trelease, On the fertilisation of our native species of Clitoria and Centrosema; Recent Literature; General Notes; Scientific News; Proceedings of Scientific Societies.

Annalen der Physik und Chemie, No. 10.—A useful paper by Herr Fromme, in this number, treats of the electromotive force of the Grove, Bunsen, and Daniell batteries, as related to concentration of the liquids. The force of a Grove, whenever this cell is traversed by a very weak current, decreases continuously with concentration of nitric acid and approximately in proportion. That of the Bunsen, under like conditions, is, for the higher concentrations, about equal to that of the Grove, but from a concentration C = 55 greater, because it remains constant, while the decrease in the Grove goes on. The force of the Grove increases with increased concentration of the sulphuric acid to a maximum between C = 25, and C = 35, and thereafter decreases at a more rapid rate.—Herr Kundt and Herr Röntgen have succeeded in proving electromagnetic rotation of the plane of polarisation in several of the less easily condensed gases; and quantitative results for air, hydrogen, oxygen, carbonic oxide, and marsh gas, are here given. The rotation is in direction of the positive current (as with water and sulphide of carbon), and its amount is approximately proportional to the density. It is estimated that 253 km. air in the north-south direction would give a rotation of 1°. The author's apparatus (including a means of compression to about 250 atm.) is described.—Prof. Lommel contributes two papers; in one of them, on Newton's dust rings, he seeks to show the adequacy of the diffraction-theory to explain the phenomena, as against the diffusion theory (interference of diffusely reflected light); in the other paper, on Stokes's law, he controverts M. Lamansky's experimental support of the general validity of this law, which he (Prof. Lommel) had before impugned, as inapplicable to a certain "critical region" in which the fluorescence and absorption-spectra overlap.—Herr Wüllner describes a five-band spectrum of oxygen obtained both from the positive and the negative light in spectral tubes, to which was admitted oxygen produced by electrolysis. When the charge of gas was allowed to stand a quarter to half an hour, the spectrum was changed into that of carbon—Herr Narr endeavours further to show that the loss of electricity by an insulated body in a gas cannot alone be explained by rise of temperature of the gas, or conduction through the insulating supports, or the presence of particles of foreign substances, as dust, water, or mercury vapour. Nor is there, apparently, a special conductivity of the gas in the ordinary sense.—The changes of density produced in steel by hardening and annealing, are indicated by Herr Fromme.—Herr Riecke has a mathematical paper on the doctrine of the poles of a bar-magnet; and Herr Gerland shows historical reason for believing that the caloric engine was conceived by Leibnitz in 1706, and that Papin is alone the inventor of the centrifugal pump.

[1] In the original a table of observations appears which we are obliged to omit for want of space, while we give the result of the same.